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(54) Fuel injection pump for internal combustion engines

(57) A fuel injection pump for internal combustion engines has a plurality of in-line pump pistons driven by a camshaft (1) which is journalled in at least two loose radial bearings (3). The camshaft (1) is also secured axially in both axial directions by means of a fixed axial bearing (14, 15, 16). The axial bearing may comprise half discs (15, 16) secured by bolts (17) to the housing (5), the half-discs being received in an annular groove (14) formed in the camshaft. In an alternative arrangement a nut having a spacer portion is screwed onto the camshaft to define the annular groove and enable an un-split bearing disc to be used.

Fig. 2

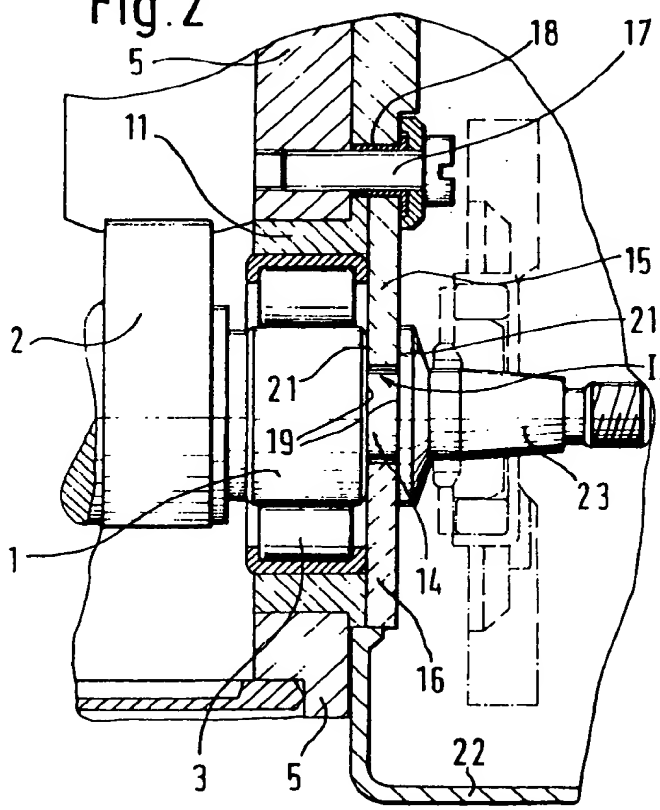

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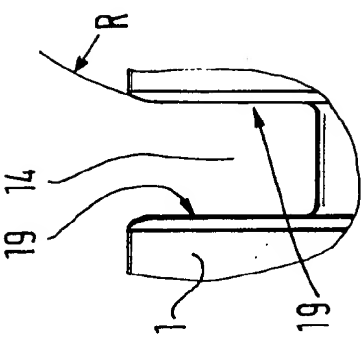
Fig.3



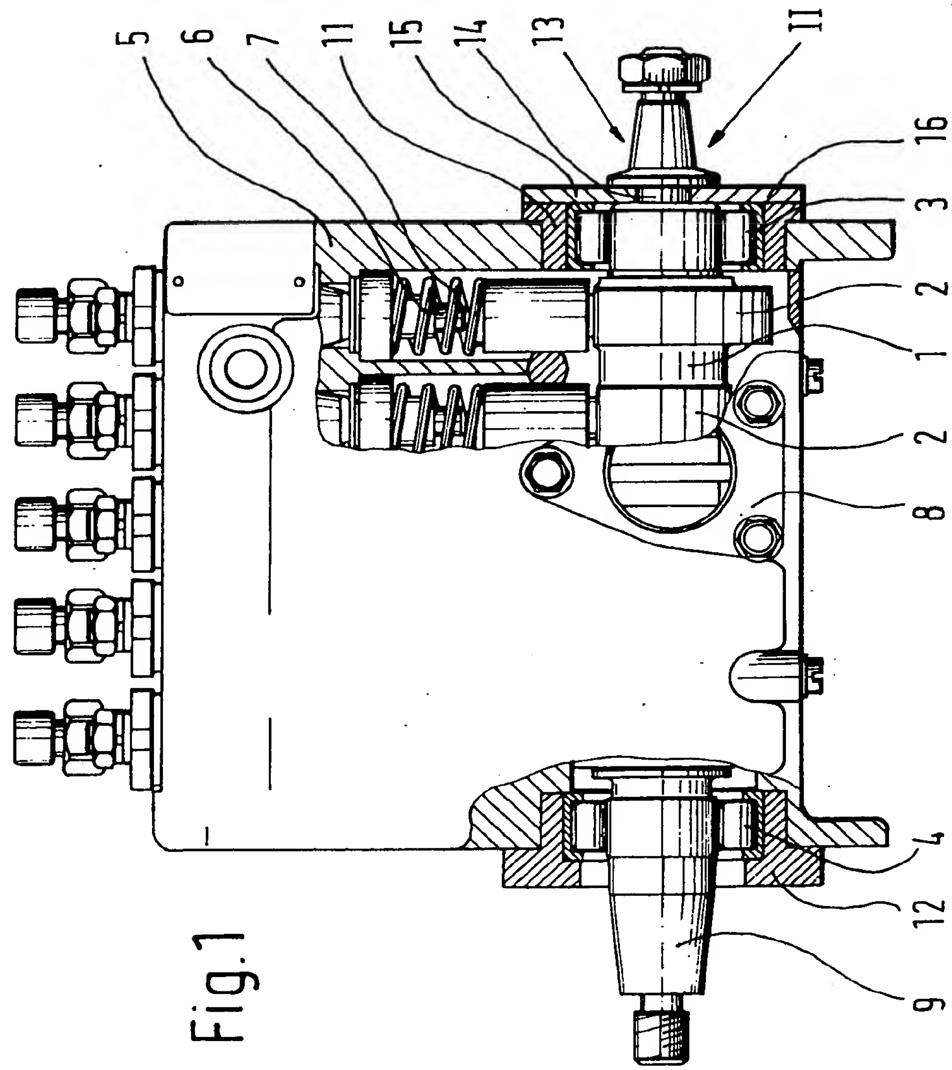
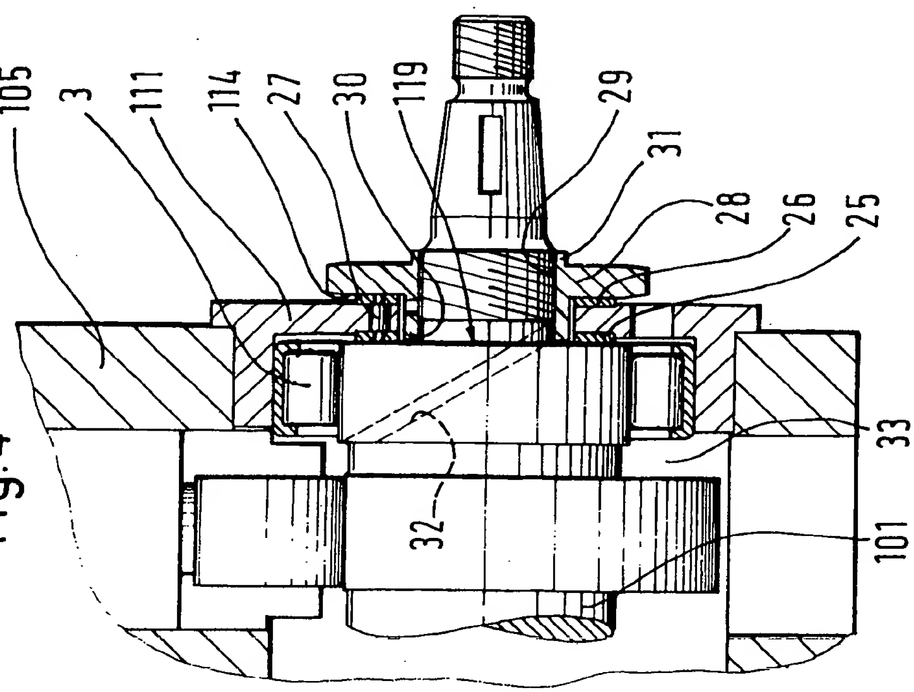


Fig.1

Fig.4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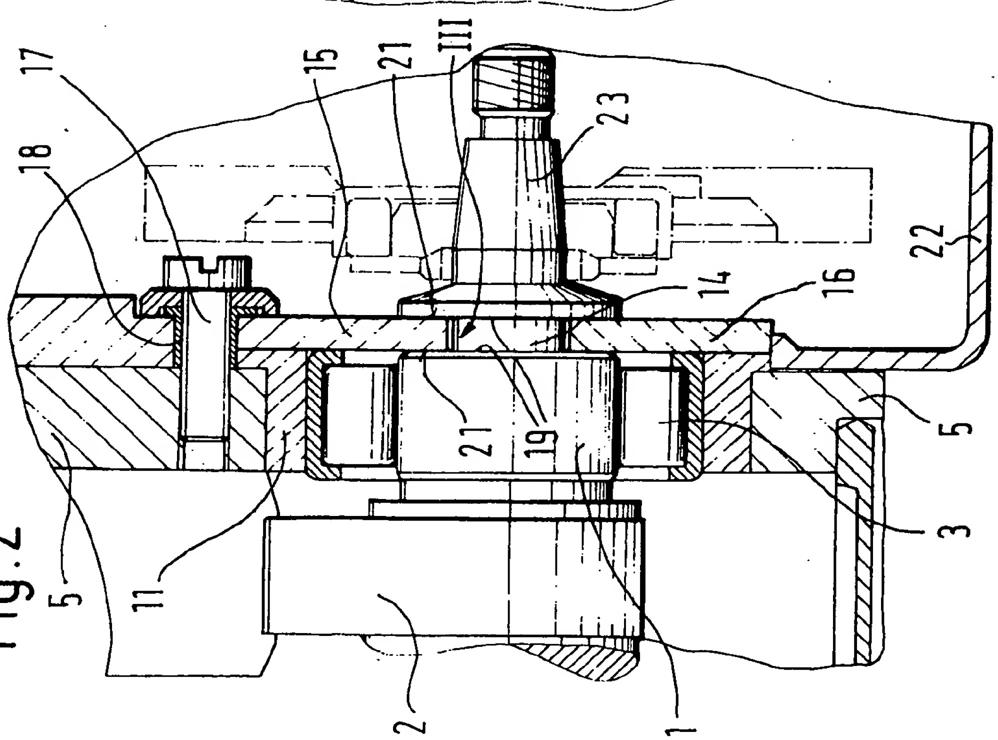
101

Fig.2


18
17
15
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III
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14
16
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1

SPECIFICATION

Fuel injection pump for internal combustion engines

The invention relates to in-line fuel injection pumps for internal combustion engines.

As result of the high injection pressures required in a so-called in-line pump, very large radial forces occur and have to be absorbed by radial bearings in such a way that, despite these radial forces, it is possible to achieve a long service life which is at least equal to that of the associated diesel engine, it being common knowledge that diesel engines have a very long service life. This requirement gives rise to realtively large bearings. As aresult of the tendency to reduce the size of the engine compartment of a motor vehicle and at the same time to maintain the performance of the engine, the designer has no option other than that of also making the injection pump as small as possible. However, the width of an injection pump is substantially determined by the diameter of the radial bearings.

In addition to the above-mentioned radial forces, the camshaft is also subjected to considerable axial forces which are produced by the helical teeth of the drive gears when the pump is operating, and also by governors when the latter are mounted on the camshaft and their tachogenerators in the form of, for example centrifugal governors convert the rotational speed imparted to the camshaft, and the centrifugal force resulting therefrom, to a linear movement and hence to an adjusting force in the axial direction of the camshaft.

A further problem which has to be taken into consideration, and which exists particularly in multicylinder injection pumps, resides in the different coefficient of expansion of the pump housing and the camshaft, so that only one axial bearing is permissible as a fixed bearing in an axial direction, although the radial bearings must be in the form of loose bearings. Hence, according to differences in the helical teeth of the drive gears, it is necessary for the axial bearing to act in one direction in one embodiment and in the other direction in another embodiment.

In a known fuel injection pump of the type described initially (Australian Patent Specification No. 19 41 92), angular-contact ball bearings serve as radial bearings and are clamped in an axial direction in the pump housing by bearing end plates. In order to compensate for the different coefficients of expansion of the camshaft and the pump housing, a resilient member is disposed between one race of an angularcontact ball bearing and a shoulder of the camshaft or of the bearing end plate. This arrangement has the disadvantage that the roller bearing is subjected to a continuous axial force and hence its durability is impaired. This axial force has to be relatively large, since, in this special case, it also has to absorb, without yielding, the dynamic axial forces to which the camshaft is subjected by the governor. That is to say faults in the governor would arise if the axial force were to yield. A further disadvantage resides in the fact that, owing to the multi-purpose function, angular-contact ball bearings of this kind havea relatively large diameter givin rise to the above-mentioned spatial problems for the designer. Furthermore, angular-contact ball bearings of this kind are expensive.

In another known fuel injection pump of this kind (US Patent Specificatiom No. 3 385221),an axial bearing in the form of an unidirectional rolling bearing is provided and cooperates with radial bearings in the form of sliding bearings which enable axial play without giving rise to any problems. This arrangement has the disadvantage that the radial sliding bearings cannot attain the required durability, and that the axial bearing only acts in one of the two directions.

A fuel injection pump in accordance with the invention has a plurality of in-line pump pistons, and a camshaft for driving the pump pistons, the camshaft being journalled by at least an axial bearing which is a fixed bearing acting in both axial directions, and two radial bearings which are loose bearings.

This has the advantage that rolling bearings, operating with cylindrical rollers and serving as loose bearings, serve as radial bearings and have a substantially smaller diameter than angular-contact ball bearings with the same transmission of radial forces, and that the arrangement in accordance with the invention may be used with or without a governor transmitting axial forces to the camshaft, irrespective of the way in which it is used, that is to say, clockwise or anti-clockwise rotation. Hence, it is possible for the designer to minimise the width of the injection pump, and the manufacturer can offer a standard type for the various purposes of use, hence considerably reducing the manufacturing costs and the cost of supplying spare parts etc. Not least, the arrangement of the two bearings for the radial bearing and the axial bearing meets the technical requirements better than in the case of the known devices.

In accordance with an advantageous development of the invention, the bearing race engages an annular groove in the camshaft on the one hand and, on the other hand, is rigidly connected to the pump housing. The actual sliding function takes place between the bearing race and the axially directed faces of the annular groove. This not only results in an advantageous saving of the installation space, but also constitutes a particularly inexpensive solution. By virtue of the resultant small average diameter of the axial bearing, errors of alignment or inclined positions of the camshaft occasioned by manufacture are also less detri-

mental during operation. In accordance with a further development of the invention, in order to mitigate the latter problem in particular, the axially directed faces of the annular groove may be of convex configuration.

In accordance with a further development of the invention, the annular groove is formed by a ring axially secured to the camshaft and a shoulder which is formed on the camshaft and whose end face is located opposite the ring, and a space provided between the ring and the shoulder. This can provide a very accurate fit for the bearing, the ring preferably being a nut which is screwed onto the camshaft, and a sleeve-like turned portion being provided on the ring or the nut to serve as the spacer. It will be appreciated that other types of fastening are conceivable, such as guiding the ring by way of longitudinal grooves, slipping it onto the camshaft and securing it axially by means of locking washers, and the spacer being in the form of a sleeve.

Preferably, the fixed bearing is a sliding bearing. There are more degrees of freedom in the construction of a sliding bearing of this kind than those existing in the case of mass-produced rolling bearings. Moreover, taking into account the desired durability, sliding bearings of this kind are adequate for the forces to be transmitted. This sliding bearing may comprise two half-discs whose parting plane extends through the axis of the camshaft and which are inserted into the annular groove in the camshaft from two opposite sides. Alternatively, however, in accordance with a further solution in accordance with the invention, the sliding bearing may be disposed on an end plate of one of the radial bearings by providing a respective bearing disc (thrust washer) at each of the end faces of the bearing end plate in the region of the axial guide of the annular groove in the camshaft. The two bearing discs separated by the bearing end plate may then be interconnected so as to be nonrotatable relative to one another by pins passing through the bearing end plate. The advantage of this second solution resides in the possibility of absorbing greater axial loads and being a solution more favourable to assemble.

The sliding bearing discs may be coated with a "self-lubricating" plastics material such as PTFE. In any event, however, the camshaft may have a bore which connects the oil chamber of the injection pump to the axial bearing for the purpose of lubricating the axial bearing.

The invention is further described, by way of example, with reference to the accompanying drawings, in which:

Fig. 1 shows a fuel injection pump partially in an external view and partially in longitudinal section;

Fig. 2 shows the portion of II of Fig. 1, drawn to a larger scale with modifications, as a first embodiment;

Fig. 3 shows the portion III of Fig. 2, drawn to a still larger scale; and

Fig. 4 shows a portion, corresponding to Fig. 2, of a second embodiment.

A first embodiment is illustrated in Figs. 1 to 3 with reference to a five-cylinder in-line injection pump.

A camshaft 1 having drive cams 2 is journalled in a pump housing 5 by means of two radial bearings 3 and 4. Pump pistons 6 are driven against the force of return springs 7 by the cams 2 during rotation of the camshaft 1. Furthermore, the camshaft 1 drives a feed pump 8 (not further illustrated) which feeds the fuel from a fuel tank (not illustrated) into a suction chamber of the pump working chambers (also not illustrated). The camshaft itself is usually driven by the engine (not illustrated) at a rotational speed in synchronism with the engine speed by way of a pulley (also not illustrated) which is to be provided on the stub shaft 9.

The radial bearings 3 and 4 are cylindrical-roller bearings which are disposed in bearing end plate 11 and 12 and, in the form of loose bearings, permit axial play of the camshaft 1.

The output end 13 of the camshaft 1 has an annular groove 14 and is usually surrounded by the speed governor of the injection pump. A sliding bearing disc comprising two half-discs 15 and 16 is pushed into the annular groove 14 from above and below and is then clamped to the housing 5 by bolts 17 (Fig. 2), the bearing end plate 11 at the same time being axially clamped. A sleeve 18 is disposed around the bolt 17 and abuts against the housing 5 and prevents the half-discs 15, 16 from being distorted. The end boundary faces 19 of the annular groove 14 slide on the outer end faces 21, presented to the boundary faces 19, of the sliding bearing half-discs 15 and 16, so that the camshaft 1 is provided with an axial guide.

As is indicated in Fig. 2, a housing 22 of the speed governor associated with the fuel injection pump is flanged to the housing 5 of the fuel injection pump. Some of the parts of the speed governor which are driven by the stub 23 of the camshaft 1 are indicated.

Fig. 3 is a fragmentary illustration of the annular groove 14 in the camshaft 1, drawn to a greatly enlarged scale. As will be seen from this illustration, the axial end faces 19 are of convex configuration with a radius of curvature R.

In the second embodiment shown in Fig. 4, the camshaft 101 is also journalled in a radial direction by means of cylindrical-roller bearings 3 disposed in a bearing end plate 111 which is secured in the pump housing 105 by means which are not shown. In this embodiment, two bearing discs 25 and 26 serve as the axial bearing and are each disposed on a respective end face of the bearing end plate

111. Pins 27 passing through the bearing end plate 11 secure the two bearing discs 25 and 26 so as to be non-rotatable relative to the bearing end plate 111 and relative to one another. The annular groove 114 is defined on the one hand by the axial end face 119 of the camshaft 101 and, on the other hand, by a nut 28 which runs on a screw-thread 29 of the camshaft 101, and by a sleeve-like spacer 30 which passes through the axial bore of the support discs 25 and 26. When the nut 28 is screwed on, the spacer 30 abuts against the end face 119 and produces the exact width of the annular groove 114 in order to prevent jamming of the sliding bearing 25, 26. In order to avoid self-loosening of the nut 28, and as is shown in the drawing, a sleeve 31 may be provided radially outwardly on the nut and, for the purpose of securing the nut, is pressable at one location into a longitudinal groove (not illustrated) which crosses the screw-thread 29. Alternatively, however, self-loosening of the nut may be avoided by choosing the direction of the screw-thread 29 in such a way that the nut 28 is automatically tightened during operation of the injection pump.

In order to obtain adequate lubrication of the axial bearing 25, 26, an oblique bore 32 is provided in the camshaft 1 and connects the camshaft space 33 to the sliding bearings 25, 26.

CLAIMS

1. A fuel injection pump for an internal combustion engine, having plurality of in-line pump pistons, and a camshaft for driving the pump pistons, the camshaft being journalled by at least an axial bearing which is a fixed bearing acting in both axial directions, and two radial bearings which are loose bearings.

2. A fuel injection pump as claimed in claim 1, in which a support ring of the axial bearing engages an annular groove in the camshaft on the one hand and is fixedly connected to the pump housing on the other hand.

3. A fuel injection pump as claimed in claim 2, in which the axial end faces of the annular groove are convex.

4. A fuel injection pump as claimed in claim 2 or 3, in which the annular groove is defined between a ring axially secured to the camshaft and a shoulder which is formed on the camshaft and whose end face is located opposite the ring, and by a spacer provided between the ring and the shoulder.

5. A fuel injection pump as claimed in claim 4, in which the ring comprises a nut running on a screwthread on the camshaft.

6. A fuel injection pump as claimed in claim 4 or 5, in which the spacer is formed by a sleeve connected to the ring.

7. A fuel injection pump as claimed in any preceding claim in which the fixed axial bearing is a sliding bearing.

8. A fuel injection pump as claimed in claim 7, in which the sliding bearing comprises two half-discs whose parting plane extends through the axis of the camshaft.

9. A fuel injection pump as claimed in claim 7 or 8, in which the sliding bearing is disposed on an end plate of one of the radial bearings by providing a respective bearing disc at each of the end faces of the bearing end plate in the region of the axial guide of the annular groove in the camshaft.

10. A fuel injection pump as claimed in claim 9, in which the two bearing discs are secured against rotating relative to one another by means of pins passing through the bearing end plate.

11. A fuel injection pump as claimed in any of claims 7 to 10, in which the bearing discs are coated with a "self-lubricating" plastics material such as PTFE.

12. A fuel injection pump as claimed in any preceding claim, in which the camshaft has an axial bore connecting the oil chamber of the pump to the axial bearing for the purpose of lubricating the axial bearing.

13. A fuel injection pump constructed substantially as herein described with reference to and as illustrated in the accompanying drawings.

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